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THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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Articles PAGE

Converting a Transit from a Straight to a Broken Type. (With Plate VII) - - - - - - - - *C. C. Smith* 345
Latitude Redetermination and Systematic Errors - *James Weir* 347
Our Galaxy - - - - - - - - - *E. G. Hogg* 357
Reminiscences of Physics and Physicists - - *Sir J. J. Thomson* 360
Nova Pictoris 1925 and Nova Ophiuchi 1933 - - *A. C. Gifford* 366
The Fifty-second Meeting of the American Astronomical Society *C. A. Chant* 373

Review of Publications

Astronomie: Tatsachen and Probleme by O. Thomas. (C.A.C.) 376

Meteor News

Willard James Fisher (Obituary) - - - - - - *P.M.M.* 377

Notes and Queries

Increase of Interest in Astronomy—Another Russian Publication—The Size of Our Galaxy—The Radcliffe Observatory. - *C.A.C.* 380

Meetings of the Society

At London - - - - - - - - - - - - - 384

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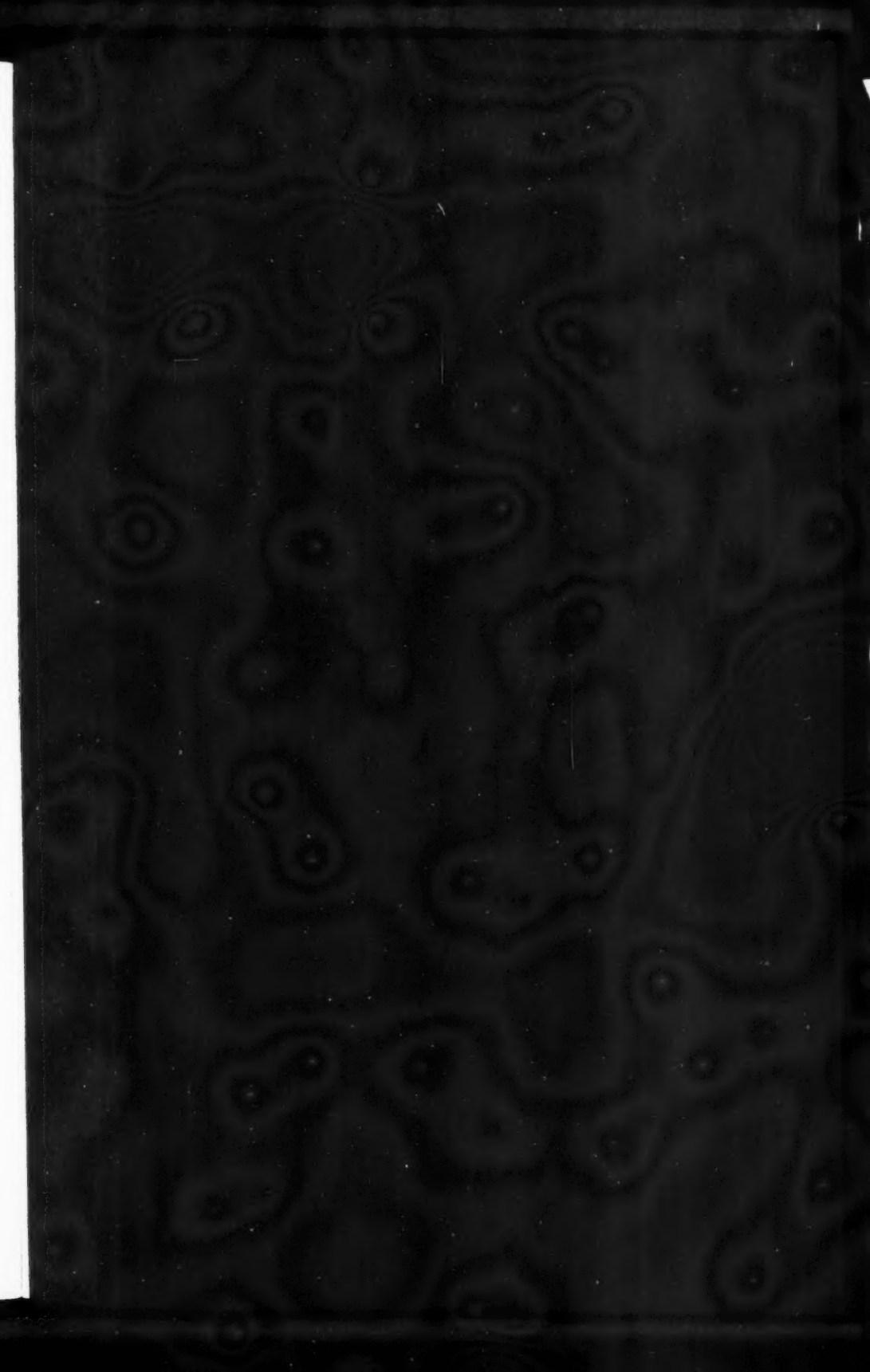

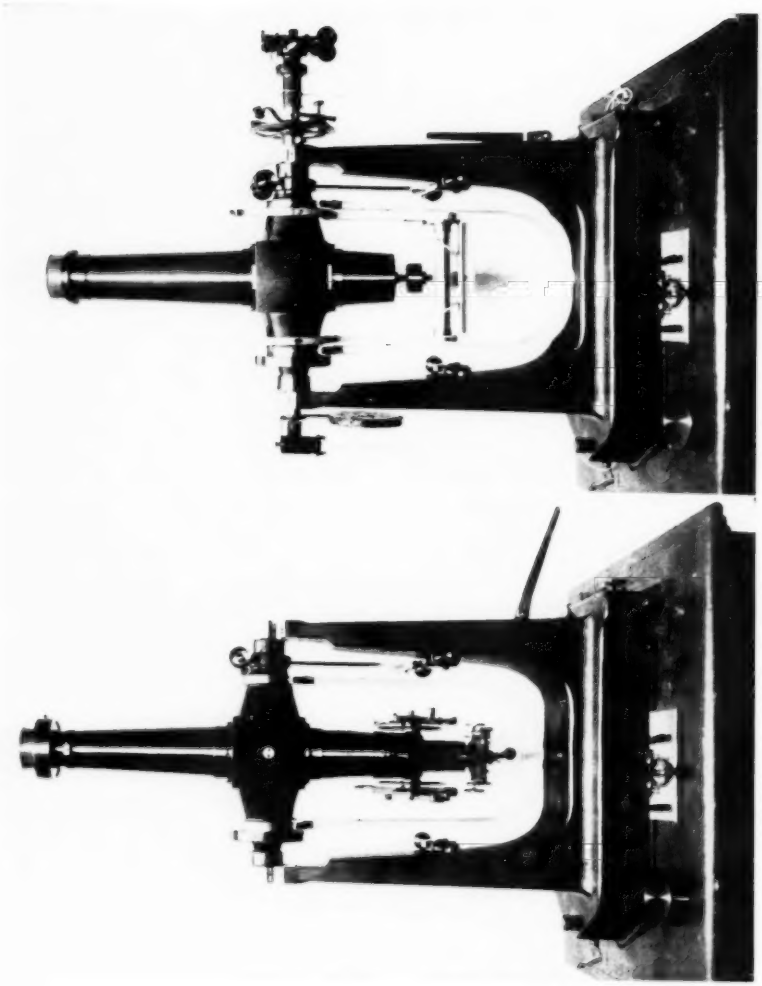

Straight Type

Broken Type

A TRANSIT INSTRUMENT, CONVERTED FROM A STRAIGHT TO A BROKEN TYPE.

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Vol. XXVIII, No. 8 OCTOBER, 1934 Whole No. 237

CONVERTING A TRANSIT FROM A STRAIGHT TO A BROKEN TYPE

By C. C. Smith

(With Plate VII.)

A STRAIGHT tube transit has certain disadvantages that can be obviated by reflecting the light rectangularly by a prism in the cube, passing it through the axis and observing with the eye-piece on an extension of one of the pivots. The advantages of this so-called "broken type" transit are: (1) That the observer's eye remains at the same convenient position irrespective of what elevation the telescope is in, and hence the errors that are due to the position of the observer north and south of the zenith are avoided; (2) the level hangs directly under the rotation axis and is read on every star; (3) the instrument is very stable and convenient to operate.

As an additional transit of this type was needed, and there was on hand a straight type Cooke of three feet focal length and a 3-inch object glass, and of very rugged design, it was decided to reconstruct the instrument in our own shop. The result is, an excellent transit at very little expense. The photographs (Plate VII) show the two instruments and the changes that had to be made. I shall add only a few explanatory remarks.

The reflecting prism, mounted on the cube end of the telescope tube, had a ¼-inch hole drilled to let the light pass for field illumination. The hole is apt to give trouble and a small prism would have been better.

The pivot, through which the cone of light passed to the focus, was a cylinder of 1.2 inches inside diameter and was made 7 inches long to take the micrometer sleeve. When such a cylinder is hardened, ground and lapped it warps and should be aged before the final lapping. The pivots were made of Jessop's tool steel.

The hanging level required some complicated castings for the mounting, since the wyes are not inset from the standards and the uprights of the reversing yoke are straight. Despite its unorthodox shape the level proved very satisfactory, due to the sturdiness of the mounting and to the fact that temperature changes have little effect.

To balance the telescope, part of the end cut off was filled with enough lead to approximately effect a balance and a large balancing nut of brass added to the end of this. The axis was balanced by a hanging disc.

In the broken type of transit any flexure of the axis is fatal and it is necessary to use counterpoising springs to take the most of the weight off the pivots. The axis of the Cooke telescope is long—an advantage, in that it decreases the effect of uncorrected pivot errors—but though the axis is unusually sturdy great care is necessary to provide against flexure. As seen in the cuts, yokes of the usual design, mounted on the top of the reversing U are pressed against the axis by spiral springs, the tension of which can (and must be) carefully adjusted. With sufficient care, trouble from these counterpoises can be avoided.

Two trains of gears were added to the micrometer, one to move the eyepiece so that the moving right ascension wires shall remain in the centre of the field of the eyepiece and the other to place the hand wheels in the most convenient position for manipulation.

This transit was used in Vancouver for the observation of clock corrections during the 1933 international longitude work, and its accuracy and convenience in use were particularly good.

Dominion Observatory,
Ottawa, Canada,
September 7, 1934.

LATITUDE REDETERMINATION AND SYSTEMATIC ERRORS

By James Weir

A BY-PRODUCT of the course in geodetic astronomy, provided for civil engineering students at McGill University, is a list of latitude redeterminations made by Talcott's method with the zenith telescope.[1,2] The record of observations in May of the past eleven years, 1924-1934 incl., made at the transit house of the Survey School at Macdonald College, Que., has been preserved. The place of observation is in latitude 45° 24′ 35″.23 and longitude 73° 56′ 35″.10, near the westerly extremity of the Island of Montreal.

From these observations, 265 star pairs, each giving a latitude result within 3″ of the mean, have been recomputed in toto by the writer, with a view to homogeneity in treatment. Of these pairs, 175 were observed by students, young men of average age 23 years, familiar with surveying instruments, and but nicely initiated into the zenith telescope method. The writer observed 90 of the pairs. The students worked in couples, about each of three instruments on adjacent piers, east and west. The selection embraces results from 75 observers, in portions of 41 nights. Repetitions, from year to year, or from night to night, have involved 96 different stars of the observing list. Some of these stars necessarily reappear frequently in the 265 selected observations. The declinations of the First Greenwich Catalogue of Stars for 1925.0 have been used, as 88 of the stars appear in this list. Eight Boss stars, (not found in Greenwich list), are included, and, for conformity, have received slight increases over their declinations in the 1900 Boss list.[3] For reductions to apparent place at the beginning of each year, the precessions and proper motions of the Greenwich or Boss catalogues were used; the independent star-numbers of the current American Ephemeris were employed in reducing to the night of observation.

The enthusiasm of the student observers is here acknowledged. The hours spent in these and other observations will, it is hoped, remain a pleasant memory with all concerned.

The opportunity presented of appraising sources of systematic errors inherent in the method is obvious. The variations in the circumstances of the programme should tend to reveal these syste-

matic effects; and that somewhat in the rôle of the lesser accidental errors, that appear as residuals from the mean result, in case of an isolated determination.

Although a careful observer may obtain in portions of several nights, a latitude result with a probable accidental error of the order of $\pm 0.12''$, systematic errors of much greater magnitude are often latent. An adjacent observer, using the same stars with a similar instrument, and at the same time, may present an equally precise result differing by $0.50''$, and interchanges of observers tend to confirm this. In effect, personal equation is important. The probable error of $\pm 0.12''$ is illusory, except as evidence of the observer's consistency.

Except on the prolonged programmes for boundary definition, the geodetic observer, making astronomic determinations for the Laplace equations—which are incorporated in the adjustment of the triangulation of a country, and used for purposes of studies of isostasy—derives his latitude from, possibly, 20 to 30 star pairs by Talcott's method. This programme may take portions of several nights; and he then goes on with other tasks. Pertinent questions he may consider include: the effects of lack of homogeneity in the star places of the various catalogues; personal equation in observing; refraction anomalies; uncertainty of his latitude level and micrometer rating; lack of balance of positive and negative micrometer corrections in the pairs secured; variation of the pole. Dismissing any alibis drawn from a Wegener shifting of the continent in geological time, his chief speculation may properly be concerned with, what result the other fellow might get, at the same place and in the same circumstances.

The latitude results in the following summary, (Table I), from the circumstances, present greater amplitude of variation than would those of one observer. They may, however, return to truth more narrowly. Curiously enough, at what appears a possible 6-year cycle (1927-1933), "depressions" beyond all expectation do occur, and regulate a growing tendency in the tabulated quantities. Has there been an unfortunate lack of compensation of errors in these years? Have abnormal refraction effects intervened? Is there any à priori ground for a 6-year cycle—though, of course, not of this

order of magnitude? Finally, did observations elsewhere show such tendencies? Anomalous change of latitude of about 0.7″ above the mean was noted in Europe in 1921,[4] but was not remarked at Greenwich. In 1903, the latitude of the Lick Observatory in California displayed an abrupt dip of 0.63″.[5] The years mentioned are seen to lie on the same 6-year cycle, if such exist, and the sense of the quantities cited are not contradictory. Harmonic constants at such an interval are large, for 6 years nearly correspond to five of the 432.5-day components.[6] However, as the precise observations of the International Latitude Service,[9] made on the same 39° parallel of latitude, in four widely different longitudes, with continuous observing of the same star list, give no indications of variations at these times, the effect must still be dismissed as highly intriguing. In this connection, it may be noted[7] that the behaviour of zenithal refraction is of great significance in the determination of astronomical constants: "The observations of the International Latitude Service have shown that the mean latitude of an evening may be in error by nearly a second of arc".[8]

Table I summarizes the results from the 265 pairs selected for computation.

TABLE I

May Latitude Redeterminations at Macdonald College, Que.

Mean epoch	No. of nights	No. of star pairs	Observed latitude	P.E. ±	Progressive mean latitude	No. of star pairs
			45°24′30.00″		45°24′30.00″	
1924.40.....	3	10	plus 5.20″	0.36″	plus 5.20″	10
1925.40.....	2	36	5.53	0.18	5.46	46
1926.38.....	4	17	5.91	0.27	5.58	63
1927.36.....	4	25	4.34	0.15	5.23	88
1928.37.....	5	34	5.23	0.16	5.23	122
1929.39.....	3	10	5.66	0.38	5.26	132
1930.39.....	2	24	6.25	0.14	5.41	156
1931.38.....	4	18	6.25	0.26	5.50	174
1932.38.....	4	15	5.49	0.22	5.50	189
1933.35.....	5	28	4.36	0.19	5.35	217
1934.38.....	5	48	4.65	0.12	*5.23	265

REMARKS

Corrections for variation of the pole, for Long. 74°, have been applied to each year's results, except 1933 and 1934, for which information is not yet available. (Bull. geod. No. 37)[9].

Arith. Mean of a total of 323 pairs, not all specially selected = 35.26″.

Weighted Arith. Mean of the 265 pairs = 35.21 ±0.14″.

Simple Arith. Mean of the 265 pairs = 35.23″ ±0.06″. *This last is preferred. The weighted mean conceals something of the precision[10].

On account of the yearly repetitions, the P.E. ±0.06″, is not strictly in accord with the principles of Least Squares, and somewhat illusory in any case.

In the graphs (Fig. 1) the straight lines join the observed latitudes of each May, at the average epoch, 0.38 of each year. The plotted values are to be added to 45° 24′ 30″.

The faintly dotted curve has been fitted to the above.

The heavy curve has been fitted to the plotted values of the mean latitude resulting from all observations up to and including each May.

The characteristics of the instruments used are given in Table II.

TABLE II

INSTRUMENTS

Designation	Maker	Type	Aperture ins.	Focal length ins.	Mag'n used	Prelim. Microm. value	Level Div.	Distribution of obs. pairs
A. 89	Troughton & Simms, London, 1913	Zenith Telescope	2.50	24	35	89″	2.10″	121
B. 88	Do. 1907	Do.	2.50	24	35	88″	1.02″	118
C. 100	Do. 1907	8 ins. Altazimuth	1.90	13½	20	100″	1.61″	26

REMARK

The first two instruments are of identical pattern.

The Micrometer Ratings

These vary with the run due to variable focus and other factors, as much as 0.04″ from the given preliminary values; and rating is required for each observation programme which has sufficient micrometer corrections of positive and negative sign to indicate the best

value for harmony in the latitude results. Ideally, the pairs observed should so balance the positive and negative micrometer corrections,

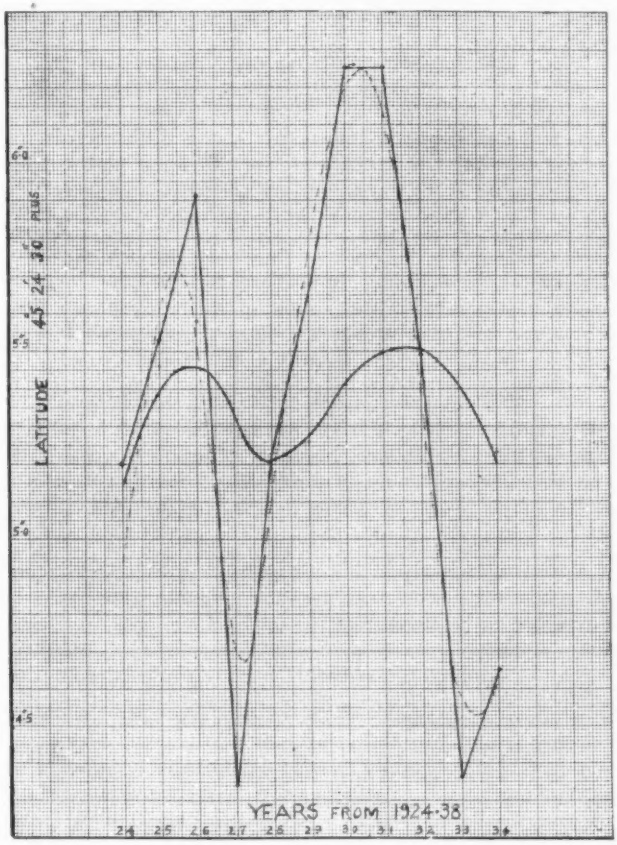

Fig. 1. Graphs of Latitude Determinations.

that the only injury to the result, from an inadequate rating, is in the greater sizes of the residuals. Rating on the movement of a star at elongation, if more direct, is only justified if an observer

monopolizes an instrument. Systematic errors from uncertain rating are introduced when the list is unbalanced in the respect noted. Lack of uniformity in the used and unused portions of the micrometer screw arise, and the measurements of unusual differences of zenith distance are wanting in precision.

Personal Equation in Bisection with the Micrometer

Time and again, one is impressed by the difference in results, equally precise, from two observers on the same night, using the similar instruments at adjacent piers and observing the same stars. Difference of the order of ½″ in the mean latitudes are not rare in these cases. Unable to attribute all of this to faulty micrometer and level tolerances, and failing to localize any definite instrumental peculiarity, one concludes that, even in this differential measurement, personal equation is not absent. The star movement and differences of focus render impracticable an independent attempt to check the bisections made. Inconsistency in the temper of the illumination is a factor. The estimated bisections of a faint and of a bright star probably differ[11]; and a reversing prism cannot, in this case, be used in correction. Probably also the error of bisection is a function of the speed of a star in crossing the field, and in this observation, a star of greater declination is paired with one of less. Bright stars become increasingly uncertain of bisection in proportion to their magnitude. Any constancy of personal equation is hardly to be expected in beginners.[12]

Latitude Levels

An originally dependable 2.33″ bubble developed erratic curvature varying from 1″ to 5″ in different parts of the scale, and was replaced by a 1.02″ vial. A second bubble has been replaced for similar, but less vicious, behaviour. It is doubtful if, in field use, a vial behaves quite as on the laboratory level triers.[13] A somewhat large tolerance in the level traverse, with students is hard to avoid. In a long programme, with some re-levelling in intermissions, the effects tend to become fortuitous; large alleged level corrections with an uncertain bubble, may affect a night's results seriously, however.

A 1-second bubble is not too sensitive for the larger instruments, as mounted, and the recorder, watching it, is sometimes enabled to protest effects of mishandling at the observer's micrometer. Heavy pressure, purposely exerted on solid concrete instrument piers set in bed rock, can be readily reflected by such a bubble. The double latitude level, which has decided advantages in detecting misconceptions, is not fitted on these instruments.

Differential Refraction

For the hours of observing in May at the locality in question, a mean temperature and pressure of 53°F. and 29.80″ respectively, are a fair estimate. The elevation of the surrounding level country is about 120 feet. A small grove of trees is adjacent to the south side of the transit house.

The differential refraction corrections[14] takes a form

$$\tfrac{1}{2}(R - R^1) = 29'' \sin (z - z^1) \sec^2 z$$

where z and z^1 are the zenith distances of the stars. As $(z - z^1)$ averages less than 20′, and the average zenith distances used are about 19°, the refraction correction averages less than ±0.18″. The unbalanced total correction was +0.02″. The night time refraction is greater than contemplated in this formula, but a very large abnormality would be required to impart any important consequences systematically. The effect of drafts through the roof traps, of lamps, observers and smoke are more serious local factors. Cramped quarters are bad in this regard. The weaving of a star about the mean position of the micrometer hair may be rarely noticed, when the smoke of a passing locomotive, 500 feet distant, is borne across. It is difficult to understand the statement[15] that observations of the International Latitude Service may show errors of nearly 1″ in a night's work from refraction effects, unless very local abnormalities are a major factor.

Star Places

As aforesaid, for uniformity, however arbitrary, the declinations of the First Greenwich Catalogue of Stars for 1925.0 have been used for 92% of the observed stars. For the 8% of Boss stars not found in this catalogue, an average addition of 0.16″ to the Boss

List[16] of declinations has been made. This addition was deduced by analogy from differences between Greenwich and Boss declinations, as tabulated by zones in the Greenwich Catalogue. This table also shows an average difference of 0.20″ between the Greenwich declinations and those of the American Ephemeris (with latest Washington corrections to Newcomb's declinations). In this case, the American Ephemeris places are the higher. A direct comparison of the two lists shows in places, differences of over ½″. However, the net effect on our latitude result, if American Ephemeris declinations were, when possible, substituted for the actual Greenwich declinations used, would have been an increase of +0.10″. The precessions and proper motions of all three lists show sufficient variations to cause considerable effects in long term reductions. It seems hopeless to expect better agreements. With the observatories, latitude and declination determinations must revolve in a somewhat vicious circle.

Star places thus constitute a fundamental uncertainty in absolute latitude determinations. Redeterminations must adhere to the original star list for valid comparisons,[17] and especially in such delicate matters as search for a secular change of latitude. The plan of the International Latitude Service of observing only on the same parallel in order that the same homogeneous star list be used throughout, and at each station, is thus the only feasible one for detection of motions of the pole. Current research in isostasy, where re-occupation of stations in random latitudes is contemplated, may thus find difficulties in the selection of an adequate homogeneous list, requiring no adulterations. The geodetic surveys of North America appear now to adhere to the Boss lists in latitude determinations for the Laplace controls, which thus may be expected on a common datum, as is their triangulation.

Station Error in Latitude

The geodetic latitude of the observing station was had by interpolations off the many visible controls of the G.S.C. triangulation of the Montreal District,[18] and is 45° 24′ 29.43″ ±0.02″. This gives the astronomic latitude greater than the geodetic by 5.80″. The unvaried nature of the adjacent topography would give no clue to

reasons for a difference of this nature. It is, however, quite in keeping with the station errors of the G.S.C.,[19] the U.S.C. & G.S.,[20] and the 45° Parallel of Boundary determinations,[21] in the larger area lying northerly from the Adirondack Mountains, in New York State and in Canada. A few only of these station errors in latitude need be cited for comparison: Rigaud, +7.62″; Covey Hill, +8.13″; Rouses Point, +3.94″.

A determination of the direction of the resultant of a larger group of such representative deviations, with the station errors in longitude included, points unmistakably to the predominant attractive effect of this Adirondack mass. A mapped funicular polygon shows a line of resultant action directly to the dome indicated by Dr. Bowie.[22]

This interesting phase cannot be here expanded.

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McGill University,
June, 1934.

OUR GALAXY*

By E. G. Hogg

IN the vast realm of space surrounding our sidereal universe or galaxy exist a great number of nebulae; many of these show the spiral structure and are regarded as being other galaxies or aggregations of stars, clusters, etc., similar to ours. The distances of some can be measured, but in most cases we can only infer them from their angular diameter, brightness, and other features they exhibit. If we know how far a galaxy is away from us and also what its angular diameter is, we can deduce its diameter in miles or light-years, and so be in a position to compare its size with that of our sidereal system. From the results so obtained Dr. Harlow Shapley has been led to divide the spirals brought into view by the most powerful telescopes into galaxies and super-galaxies; our sidereal system is placed by him in the latter class, as in his opinion it largely transcends in magnitude the majority of the galaxies around us. If these are to be regarded as "islands" then our system is a "continent".

Many astronomers have, however, felt some difficulty in accepting Shapley's estimate of the dimensions of our galaxy and believe that he has overstated its magnitude very considerably. His results were deduced mainly from the distances from the sun of the globular clusters which form a system enclosing the stars and nebulae belonging to our galaxy, and there seems good reason to believe that his computations of these distances are largely in error through the omission of a factor whose importance was not recognized when he made them.

Shapley's calculations were based on the assumption that space was transparent, whereas there is an accumulation of evidence that between us and the distant globular clusters there is an absorbing layer of cosmic dust or haze, to which is due the marked reddening of the stars lying in low galactic latitudes. Photographs frequently

*Written by E. G. Hogg for *The Press*, and published in the Astronomical Notes of the New Zealand Astronomical Society (October, 1933).

show that the diametral plane of a spiral nebula seen edgewise is obscured by dark markings, which suggest that the light from that part of the nebula is cut off by intervening masses of cosmic haze, which are congregated most densely along the diametral plane, and it is quite probable that our galaxy is also enveloped in a similar haze. Some time ago Trumpler investigated the effect of this haze upon the colours of the stars in the open clusters, and quite recently Stebbins has published the results of an investigation of the colours of the globular clusters which from their great distances and high intrinsic luminosities are very suitable for testing the transparency of intervening space.

Trumpler's researches had reduced in fair measure Shapley's estimate of the dimensions of our galaxy, but Stebbins' work has profoundly altered it, and if his results are confirmed our sidereal universe loses its claim to be regarded as a super-galaxy. Shapley calculated its diameter to be about 80,000 parsecs or 250,000 light-years, but Stebbins finds for it a diameter of only 30,000 parsecs or 94,000 light-years. This new estimate not only renders the general form of our system more symmetrical and more condensed about its centre, but also makes it much more comparable in size with other external systems of similar form; its diameter is now only three times instead of eight times that of the nebula in Andromeda.

The Distribution of Galaxies

Some decades ago the idea that our galaxy occupied a prominent and privileged place in the universe would have been accepted as only natural and proper, but now the pendulum has swung far in the other direction and present-day preference is to regard it as an insignificant unit among an unnumbered host of similar companions. The old notion was perhaps fostered by the belief formerly held that the spiral nebulae were congregated most thickly in the direction of the galactic poles. We may remind readers that our system is supposed to have roughly the form of a double-convex lens, the medial plane of which divides the Milky Way into two equal parts; the galactic poles lie in the direction at right angles to this plane.

Shapley has recently published the results of an investigation into the distribution in the heavens of about 100,000 galactic sys-

tems. Photographic plates have been taken over all parts of the sky, and the number of galaxies in each square degree down to the magnitude 18.2 have been counted. His analysis of this material demonstrates clearly that there is no marked clustering towards the galactic poles, the systems being fairly evenly spread over the high galactic latitudes in both hemispheres. The northern regions are richer in galaxies than the southern, but this result is probably due to the fact that the sun lies some considerable distance—perhaps 4,000 light-years—north of the galactic equator. Another important result is the confirmation of the long-known fact that these external systems are almost entirely absent from low galactic latitudes; this apparent avoidance of these latitudes supplies overwhelming evidence of the cosmic haze to which we have already referred. We cannot doubt that external galaxies exist in these directions, but the light from them is almost entirely absorbed by the haze through which it has to pass before it reaches the earth; it is not until we have come to galactic latitudes 20 north and south that these external systems begin to appear in any numbers. We have then to supplement our picture of the lens-shaped galaxy to which we belong by imagining that it is enveloped in a cloud of cosmic haze which lies most thickly along the equatorial plane and thins out as we approach the galactic poles.

REMINISCENCES OF PHYSICS AND PHYSICISTS*

By Sir Joseph J. Thomson

I WENT to the Owens College, now the University of Manchester, through a mere accident. It was intended that I should be an engineer, and in those days the only way to do this was to be apprenticed to some big engineering firm. The firm I was to go to had a very long waiting list and told my father it would be a long time before I could be taken on. A friend to whom my father mentioned this said, "If I were you I should send him while he is waiting to the Owens College; it must be a pretty good kind of place, for young John Hopkinson, who was educated there, has just come out senior wrangler." My father took this advice and I was sent to Owens when I was not fifteen years old; this was thought such a scandal that the authorities passed a resolution that in future no one under sixteen should be admitted.

In those days the college was a house in which Cobden had lived; it was by no means large and we were much cramped for space. The lectures on engineering were given in what had been the stable, and the drawing office was a converted hay loft. But though the building was so poor, few universities have had such a brilliant staff of professors. There was Balfour Stewart for physics, Roscoe for chemistry, Osborne Reynolds for engineering, Thomas Barker for mathematics, W. Crawford Williamson, the great paleo-botanist, James Bryce, who was afterwards ambassador to the United States, Adolphus Ward, the historian, who afterwards became Master of Peterhouse, and Stanley Jevons, the political economist.

The teaching at Owens College sixty-three years ago was as good as I could get anywhere if I was beginning my studies now. My first introduction to physics was the lectures of Balfour Stewart. These were so clear that, child as I was, I could understand them. He was a very interesting man with a strong metaphysical turn, and with P. G. Tait wrote a book "The Unseen Universe" which attracted

*A portion of a Friday evening discourse before the Royal Institution of Great Britain.

a good deal of attention when it appeared. Barker, the professor of mathematics, though as far as I know he never published a paper, was as good a teacher as any one I ever came across. His methods were not altogether orthodox, since under him I learned quaternions before Cartesian geometry. I do not think this order would in general be recommended, but I think we worked the better for it, we looked upon ourselves as pioneers and felt that it was up to us to make good.

As I was taking the engineering course the professor I had most to do with in my first three years at Owens was Osborne Reynolds, who, too, forms a connection with the Royal Institution. He was one of the most original and independent of men and never did anything or expressed himself like any one else. It was difficult to take notes at his lectures, the result being that the student had to read his text-books more diligently. In fact, it was only in his Friday evening discourses at the Royal Institution that he expressed himself so that he could be immediately understood. He was a great personality, one of his outstanding characteristics being that when he took up a problem he began to think it out for himself from the beginning. This I think is a better way than that of beginning by forming a bibliography and reading the literature. Many people's minds are more alert when they are thinking than when they are reading, and they are less apt to accept as satisfactory some plausible explanation which will not bear criticism. Osborne Reynolds did important work on the discontinuity of the motion of a fluid flowing through a pipe (a fundamental constant in this subject is called the Reynolds constant), on lubrication, on the calming of waves by rain, on the singing of a kettle and on the reason why sound travelling against the wind is not heard as well as when it travels with it. He worked out with great success the consequences which follow from the fact that a collection of equal spheres can be "piled" in different ways, and brought before the Royal Institution many beautiful illustrations of these. He worked out a theory of the universe on the assumption that it consisted of a large number of spheres in contact, and claimed that it was the one, and the only one conceivable, purely mechanical system capable of accounting for all the physical evidence as we know it.

In the early seventies the outstanding subject of interest in physics was Crookes's radiometer, or light mill, which in its commonest form consisted of a system of vanes which could rotate round a pivot supported in a cup of glass. These vanes were blackened on one side and bright on the other and when a light was brought near them they rotated, the direction of the rotation being the same as if the blackened side were repelled by the light. They aroused very general interest, and shopkeepers had them rotating in their windows to attract a crowd.

The discovery of the radiometer by Crookes was a triumph of vigilance in observation and accurate measurement. When he was engaged in making very accurate weighings to determine the atomic weight of thallium, an element which he had lately discovered, he found small discrepancies which he could not account for by any known source of error. He set himself to trace the origin of these, and by ingenious experiments convinced himself that they were due to light falling on the balance. This led him to make *ad hoc* experiments on the effect of light on delicately poised pieces of metal, and hence to the radiometer. At first the rotation was ascribed to a pressure exerted by light on the vanes; such a pressure exists, but in normal conditions the direct pressure of light is far too small to produce rotations such as those which occur in a radiometer. They turned out to be due to the blackened surfaces getting hotter than the bright ones, owing to their absorbing more light. When the molecules of the gas strike against the blackened side they get hotter and shoot off with a higher velocity than when they strike against the bright one, so that the kick or recoil is greater on the blackened surface than on the bright.

Though the radiometer did not yield anything as fundamental as had been hoped, and it may be said deserved, yet it was the means of leading Crookes to devote himself to the study of high vacua and to cathode rays. The work occupied him for many years and resulted in some of the most beautiful experiments known to physics, with which year by year he delighted audiences at the Royal Institution. These led him to a conception of a fourth state of matter, a state in which the molecules of the gas were so far apart that they could travel across the vessel in which they were contained.

He said, and said quite truly, that the properties of such a gas would be quite different from those of one at ordinary pressures, when the molecules can not go more than a very small fraction of a millimetre without coming into collision with another molecule. It turned out, however, and this was first announced at a Friday evening discourse in this room, that the cathode rays were not merely molecules of the gas moving without interference from other molecules, but that they were very much smaller particles—electrons—knocked out of the molecules of the gas, and that these small particles were of the same kind from whatever kind of gas they proceeded, showing that the electron was a constituent of every kind of substance.

Towards the end of the seventies there was an outburst of researches on the passage of electricity through gases, a subject whose vital importance in connection with the structure of molecules and atoms was just beginning to be realized. Warren de la Rue and Müller, Spottiswoode, Moulton and Schuster all made important researches in this branch of physics. The experiments of de la Rue on striations in the electric discharge are of quite exceptional interest and beauty. The "Friday evening" at which he gave an account of them was on the heroic scale. The preparation of the experiment occupied, I believe, nine months. He set up in the institution, for his lecture, a battery of 14,000 cells. The tubes which I have before me on the table, and which have remained in the institution ever since the lecture more than fifty years ago, are witness of the abundance of the experiments with which the lecture was illustrated. It was rumoured that he spent many hundreds of pounds on its preparation.

With the nineties began a series of discoveries following one another in quick succession, to which that much-abused term "epoch making" may be appropriately applied.

In 1891 in one of the lectures given in commemoration of the centenary of the birth of Faraday, Dewar exhibited liquid oxygen in bulk, following this first with liquid air and then with liquid hydrogen. He continued his low temperature researches for many years. Two of the discoveries he made were even greater achievements than the liquefaction of gases; one of these was the vacuum jacket, im-

pervious to heat, called the thermos flask, but which ought to be called the Dewar flask, which has been a joy and comfort and a help to millions spread over every country in the world. The other discovery was that of producing high vacua by absorbing the gases by charcoal cooled with liquid air. Most of the discoveries in modern physics have been made by studying molecules as individuals and not as crowds. To do this we must have high vacua. Every improvement in the vacuum has resulted in new discoveries. The charcoal method gave us better vacua than we had had before and many important discoveries could not have been made without it.

In 1894 argon was discovered by Lord Rayleigh whom both the Royal Institution and the Cavendish Laboratory can claim as one of their professors. This discovery is one of the romances of science; it has been described more prosaically as the triumph of the third place of decimals. It was due to Lord Rayleigh finding that the weight of the gas in a vessel was 2.31 gm. when the vessel was filled with nitrogen obtained from the air, while it was only 2.30 gm. when it was filled with nitrogen obtained from chemical compounds of nitrogen. This difference, less than one half of one per cent., led, in the hands of Lord Rayleigh and Sir William Ramsay, to the discovery of the new element argon. It is a striking example of the way accurate measurement may lead to most fundamental discoveries. It seems hardly possible, however, that any discovery would lead to more startling results than this, for it was found that more than 1 per cent. by weight of the atmosphere consisted of argon, so that there are pounds of it in a fair-sized room and hundredweights in most chemical laboratories. Moreover, the discovery was not made by using some new-fangled physical apparatus of which chemists are so shy, but by the balances which abound in every chemical laboratory and in the use of which chemists are expert. No wonder the chemists were incredulous; they could not believe that with their delicate methods, by which they can detect fractions of a milligram of most substances, they could have missed pounds of argon. It is the most wonderful case on record of a successful attempt at escape from detection, and succeeded because argon, so to speak, kept itself to itself, and would form no alliances with the most attractive brides offered to it by the

chemist. But though argon had taken the measure of Scotland Yard it had forgotten Sherlock Holmes and when he took a hand the game was up. Besides the discovery of argon, 1894 was memorable for Hertz's discovery of electric waves. The "Friday evening" given by Sir Oliver Lodge on this discovery was one of the most outstanding in the long roll of these discourses. The next year marked the discovery of Röntgen rays. It would, I think, be a striking example of the importance of research in pure physics in promoting employment, if we had the figure for the number of people in this country employed in the industries created by the discoveries made in the decade 1890-1900; the number of people employed in the manufacture of thermos flasks, in broadcasting, in the manufacture of the instruments used for wireless and for the medical applications of Röntgen rays.

NOVA PICTORIS 1925 AND NOVA OPHIUCHI 1933*

By A. C. Gifford

1. Nova Pictoris 1925

A LITTLE before 6 a.m. on May 25, 1925, Mr. Watson, of the Post and Telegraph Department, Beaufort West, South Africa, noticed a bright star near Alpha Pictoris. He could not recognize it, and felt convinced it was a nova, and therefore telegraphed to the Cape Observatory. Fortunately the evening of the 25th was clear at the Cape. The discovery was confirmed, and observations were taken of its position, magnitude, and spectrum. The star appears in Harvard photographs taken in 1889 and 1890, and photographs showing it have been found for every year since 1894. During all that time, until 1925, the star showed no variation in brightness. It was still normal on December 26, 1924, and was probably so on January 13, 1925, when photographs showing stars of the eleventh magnitude gave no trace of it. But now we come to a very mysterious fact. A Harvard circular says that on April 13, 1925, the star was of the third magnitude. Does this mean that a great opportunity was missed? We have seen repeatedly that the rise of a nova to its maximum is usually extremely rapid, whilst the decline is fitful and very much slower. Now the behaviour of Nova Pictoris, after its discovery, was very unusual. The principal observed maximum did not occur until June 9, fifteen days after it was first seen, and its subsequent decline was slow with unusually great fluctuations. By July 6 the magnitude had fallen to 3.6. On July 27 it sprang to 1.7. Then, after falling on August 4 to 3.25, it rose again on the 9th to 1.8. After that the decline became more rapid, but still with strongly marked oscillations. A period of five days seemed to be superposed on one of 13 days, and there were many further complications. Judging by the light curve alone it looks as if the chief maximum had been completely missed. If the brightness increased

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about April 13 from magnitude 12.75 to magnitude 3, we should expect it to have reached its principal maximum very soon after. If this were so the phenomenon was missed entirely. We have no positive evidence, and little negative. Mr. Reid, the well-known comet discoverer, does not think the nova can have been much brighter than the sixth magnitude on May 21, as he set his comet-seeker on this region and did not notice it.

Nova Pictoris differs from most of those we have already described in several important respects. It is situated far from the galactic plane, and near the great Magellanic Cloud. Its galactic latitude is 62deg 34min 34sec south. If there was an unobserved principal maximum, we know nothing about it. If the maximum of June 9 was the main one the rise was unusually prolonged, and the fluctuations set in unusually early in the decline. The spectral changes appear to have been unusually complicated. On May 25 the dark lines of hydrogen, iron, titanium, scandium, chromium, calcium, strontium, and magnesium were heavy and broad, whilst the bright lines by which some of them were bordered on the red side were then narrow. The absorption lines at that time indicated only an approach of about forty miles a second. But soon there was abundant evidence of selective atomic escape, and the expulsion towards us of several jets of gases at speeds which rose in some cases by December to over 800 miles per second. We talk about the changes in Nova Pictoris being unusually slow, but in reality they betoken an astounding explosion. The parallax of the star has been estimated to be about .006. This means that it is over 800 light years away. At its maximum it must have shone with an intensity greater than that of 8800 suns. During the outburst the radiation increased 44,000 times, so we must picture the encounter taking place between two stars whose combined radiation amounted only to one-fifth of that of the sun. But the comparative slowness of the changes shows that one at least of the stars was a giant, that is a star of very low density. Neither of them could have been very hot, as stars go. Probably both were M-type giants. In the case of stars like our sun, the collision takes place and the third body is formed in less than an hour. The encounter between two giant stars may take a week or more. During all this time the material taking

part in the collision is crowding towards the centre. The lighter elements which formed the surface layers of the colliding stars are compressed by heavier substances torn from deeper down. The heavy materials at the ends of the newly formed spindle-shaped mass are moving in oposite directions. Thus a new rotation is imposed on those with which the masses were endowed in the parent stars. There is thus formed the most complex and unstable body in the heavens. The third body formed from a pair of giant stars is itself of enormous dimensions, though it may be no more massive than one formed from a pair of dwarfs. It is therefore more leisurely in its behaviour. The high temperature produced by the sudden stoppage of forward motion causes the outer layers to form an expanding atmosphere. The inner portions undergo alternate compression and expansion, these motions being added to the complex rotations. The relative velocity with which the encounter begins is comparatively small in the case of giant stars. Two dwarfs like our sun meet with a relative speed of nearly 400 miles per second. If each had been expanded to a hundred times its original diameter, the speed of impact would be only forty miles a second. Especially at first, what we see depends on the portion of the turbulent mass which is facing us. If the end of the spindle points in our direction, the light of the nucleus has to struggle through the shallow atmosphere of varied elements, and the continuous spectrum is crossed by dark lines. In Nova Pictoris, as we have seen, this atmosphere at first was moving towards us at only forty miles per second. Later the light elements robbed so much energy from the heavy ones that they acquired speeds of 800 miles per second. The heavier elements drawn inwards from the ends of the spindle compress the lighter gases and drive them out, especially from regions of weakness which form an irregular belt about the revolving mass. Whenever one of these regions is presented directly towards us, a jet of hydrogen, helium, and other gases starts towards us. But all the time equipartion of energy is accelerating the speed of the light elements at the expense of that of the heavier ones. Successive pulses thus give absorption lines displaced successively more and more towards the violet. The history of this nova is worthy of careful study, but the complete gaps in its record, extending from January 13 to April

13, and then again from April 13 to May 25, make a full interpretation difficult. It is to be hoped that the next nova may soon appear, and that it will be discovered during its first rush to splendour. It may then be possible to correlate, more perfectly than has yet been done, all the fluctuations of the light curve with the spectral changes. Astronomers should then be able to separate the effects of pulsation from those of rotation, and tell what part of the exploding mass is facing us at each stage. The encounter theory explains so well the character of the light curve and the series of changes in the spectrum that it seems worth while to test it by applying it to the finer details. Again, since the stars may be single or multiple, dwarfs or giants, solitary or accompanied by planets, and of any spectral type, we may have long to wait before observing all predicted varieties of novae.

2. Nova Ophiuchi 1933

On August 17, 1933, the Dominion Astronomer received a message from Melbourne stating that a nova had been discovered in the constellation Ophiuchus by L. C. Peltier, of Delphos, Ohio. No further information was given of its position, but it was stated to have been of magnitude six on August 15. A search was started at the city observatory on the same evening. Ophiuchus is a large constellation, very irregular in shape, Serpens and Scorpio making curious indentations in it. No trace could be found of any uncatalogued star. Fortunately Mr. I. L. Thomsen made also a photographic survey of the whole constellation, and the plates were compared with the Franklin-Adams charts. Nothing brighter than 8 or 7.5 in magnitude was found.

Later information has shown that the nova is identical with the variable star RS Ophiuchi, which is also known as Nova Ophiuchi No. 3, 1901. Apparently the outburst was practically over before the news reached New Zealand.

From 1880 to 1891 its magnitude was 10.9. In 1894 it became half a magnitude brighter. On May 31, 1898, it was observed to be 10.8, but on June 30 it had risen to 7.7. By October 8 it had sunk back again to 10.8.

The recent outburst was first noticed by E. Loretta, of Bologna. He found it to be of magnitude 7.5 on August 10. On the next

five nights its brightness was estimated at 5.8, 4.3, 5.1, 5.8, and 6.0 respectively. It appears on one of the plates taken by Mr. I. L. Thomsen on August 18 as of 7.6 photographic magnitude.

The special interest with regard to this nova is that it forms a sort of connecting link between typical novae and variable stars. Its light curve during this outburst is just like that of a typical nova, except that the increase in brightness was much less than usual. But even so the sudden change was at least 6.5 magnitudes, which means an increase of almost 400-fold in brightness. The rise, like that of a typical nova, appears to have been very rapid, the decline rather less so. At each outburst it exhibited a nova-like spectrum, with bright emission lines due to hydrogen and ionized helium.

The constellation Ophiuchus in which this outburst occurred has been the scene of several others. The celebrated nova of 1604 was near Xi Ophiuchi, in the southern part of the constellation, which lies between the Eagle, the Archer, and the Scorpion. This whole region is full of celestial marvels. During the last century five novae have been observed in Ophiuchus, but this record is much surpassed by Sagittarius in which thirteen have been discovered during the last thirty-five years. RS Ophiuchi is very close to the border of the constellation, and about four degrees south-west of Zeta Serpentis. It is close to the Cepheid variable Y Ophiuchi, but during its temporary splendour it was easily distinguished by its colour which was deep red, due to the abundance of radiation from glowing hydrogen, whilst Y Ophiuchi is a yellow star.

The most celebrated of the irregular variables to which class RS must now be considered to belong is Eta Carinae, or Eta Argus as it used to be called. This is in the glorious portion of the Milky Way not far from the Southern Cross. The variable is on the edge of the Keyhole Nebula. It was observed by Halley in 1677, and for the next century and a half it appears to have varied between the second and fourth magnitude. In 1827 it rose to the first magnitude and then sank to the second during the next three years. In 1843 it became the second brightest star in the sky, being surpassed by Sirius alone. Since 1886 it has been invisible to the naked eye with a magnitude about 7.5. Its spectrum consists chiefly of bright

lines due to hydrogen and ionized iron. Now how do these connecting links between novae and variable stars affect the impact theory.

Bickerton showed that a grazing collision between two stars besides giving birth to the spectacular third body must create a lake of fire on each star. They are thus turned into a pair of revolving variables. Then the attraction of the third body must reduce the velocity of the retreating stars, and if the mass of the part cut off exceeds a certain value it must wed the two into what is known as a double star. The stars revolving in elongated ellipses may in some cases collide again. Thus recurring impact may give rise to two or more distinct nova--like outbursts. Then again all encounters cannot possibly be confined to solitary stars. Double stars, multiple stars, and stars with families of satellites must sometimes be involved. Every impact scatters nebulosity around, and this nebulosity is sure to be noticeable when successive impacts occur within it. The complicated encounters between multiples and systems must give rise to irregular outbursts with several maxima. These, however, appear to be less common than the grazing impact of two single stars, a type of encounter which leads to a startlingly sudden transformation of energy, and a rapid decline in brightness from one very distinctly marked maximum. We have seen that this suddenness in the rise and in the decline seems to provide a fatal objection to the theory that the outburst is due to a star entering a nebula.

But nowadays when tremendous forces are known to be confined within the atom, an appeal is often made to these forces acting in some unknown way. Some writers think that energy, liberated from the atoms, is confined within the star until at last the latter bursts with a terrific explosion. Others say that quite a small body of planetary dimensions may strike and penetrate a star within which such pent-up energy is stored, and that the blow starts the explosion by what may be compared with trigger action, the violence of the resulting explosion being terrific in comparison with that of the blow which started it.

With reference to all such theories we may say that if known forces and known scientific principles afford a satisfactory explana-

tion of any phenomenon it is unnecessary to invoke the action of unknown ones.

But all such theories are open to a more fatal objection. If a star explodes the mass still exists to exert its restraining gravitational effect. The outrush of gases will take place with a diminution, not an increase of velocity. At the beginning of the explosion the elements intermingled in any part of the star will have approximately the same temperature, and so there will be little opportunity for the atom sorting or selective atomic escape, which is so marked in the third body. Unless the entire mass of the exploding star starts outwards with hyperbolic velocity, most of it after scattering will be drawn together again. Instead of the planetary nebular stage of the third body and the pair of variables little brighter than before the collision we shall have a pulsating cepheid variable which will take thousands of millions of years to return to the magnitude of the star before the collision. The quick decline in a few weeks or months is the test which seems to eliminate all theories of novae advanced up to the present time, with the single exception of the partial impact one. The only serious argument advanced against it is the a priori improbability of stellar impact, and the strength of this argument depends on the assumption that dark stars are not much more numerous than bright ones. This assumption may be quite unsound. Until something better is proposed, partial impact should be used as a suggestive working hypothesis.

THE FIFTY-SECOND MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY

By C. A. CHANT

THE fifty-second meeting of the American Astronomical Society was held September 10 to 12, 1934, at New London, Conn. This place was chosen on the invitation of Professor G. K. Daghlian of Connecticut College. This is the latest founded of the considerable number of great colleges for women to be found in the eastern states and I think most of the members were filled with surprise and admiration at the magnitude of the institution, the beauty of its site with its 325-acre grounds, and its artistic and permanently constructed stone buildings. Dormitory accommodation was provided in Windham Hall and the sessions for papers were in Fanning Hall.

The first session was on Monday, September 10, at 2 p.m. Dean Irene Nye of Connecticut College gave an address of welcome. She stated that the college was opened in 1915 with a freshman class of over one hundred. Last year the enrolment was 633 and the faculty numbered 70. The college is supported by fees and the interest on endowment. The first president was Frederick Henry Sykes, who graduated from the University of Toronto in 1885 and was well known as a teacher in Toronto before he went to the United States. The sessions continued on Tuesday morning and afternoon and on Wednesday morning. At the close of the session on Tuesday afternoon the members and their friends went by motor some thirteen miles westward to a hamlet named Salem, near which is a 60-acre farm belonging to Professor E. W. Brown, of Yale. After leaving the highway "at a cobble-stone post", a narrow, tortuous, hilly road through thick woods leads to the clearing around the little farm house. The visitors were received at the gate by Professor Brown, and then passed beside the old well-sweep, still in use, and on to the banks of a small stream. In these picturesque surroundings a bountiful supper was provided by Connecticut College. The weather was agreeable and the occasion was altogether delightful.

To fill the vacancy in the Council of the Society caused by the death of Harriet W. Bigelow, who passed away in Java while on a trip to the far east, Mrs. Cecilia Payne Gaposchkin was elected. During the year eighteen new members were added, while twenty died or allowed their membership to lapse. The present membership is 530. Director Stewart of Ottawa and the present writer were the only members from Canada at the meeting. The next winter meeting will be at the Franklin Institute, Philadelphia, and the next annual meeting will be held in September, 1935, at the David Dunlap Observatory, University of Toronto.

Following are the titles of the papers presented:—

C. B. WATTS, P. SOLLENBERGER, and J. E. WILLIS: Longitude operations at San Diego and Washington in 1933.

ISABEL M. LEWIS: A method for the selection of stars to be occulted at any place during a given interval of time.

H. R. MORGAN: The nutation constant from circumpolar observations.

P. VAN DE KAMP and A. N. VYSSOTSKY: The accuracy of positions from photographic plates treated by the normalizing process.

F. L. WHIPPLE: On the colors of external galaxies.

DIRK BROUWER: On the determination of systematic errors in star positions from observations of minor planets.

J. H. PITMAN: The determination of the mass-ratio in visual binary systems.

JAN SCHILT: Analysis of proper motions with the aid of the Hollerith tabulator.

SERGEI GAPOSCHKIN (introduced by Cecilia Payne Gaposchkin): Changes of period for cluster type variables.

D. B. McLAUGHLIN: The semi-regular variable RS Cancri.

T. E. STERNE (introduced by Harlow Shapley): Right ascension errors in trigonometric parallaxes.

CECILIA PAYNE GAPOSCHKIN: Red standards in the Harvard standard regions.

F. L. WHIPPLE and L. E. CUNNINGHAM: The orbit of the Reinmuth object.

P. VAN DE KAMP: A determination of the upper limit of internal motion in the Praesepe cluster.

CECILIA PAYNE GAPOSCHKIN: The Harvard photographic photometry, $+15°$ to $+25°$.

J. A. PEARCE: Spectroscopic elements for the eclipsing variables TX Ursae Majoris, MR Cygni.

E. A. FATH: Atmospheric absorption at the Lick Observatory.

ZACCHEUS DANIEL: The parallaxes of one hundred stars.

E. F. CARPENTER: A cluster of extra-galactic nebulae in Hercules.

W. W. MORGAN and B. A. WOOTEN: Relative stellar energy curves in the infra-red.

R. M. PETRIE and R. R. MCMATH: A short-lived solar disturbance.

W. J. FISHER: A relation between finds of iron meteorites in North America and glacial times.

LEAH B. ALLEN: Note on the errors of photo-visual magnitude in selected cases.

E. M. LINDSAY and B. J. BOK: Report on the progress of the Harvard program of star counts.

B. BOSS: The relationship of absolute magnitude to radial velocity and galactic distribution.

REVIEW OF PUBLICATIONS

Astronomie: Tatsachen und Probleme, by Oswald Thomas in Vienna. 584 pages, 5¾ × 9 in., with 31 plates and 275 line drawings. Graz: Verlag "Das Bergland-Buch", 1934.

This book is not constructed on the usual plan of our text books but it might well be used as one. It shows an exhaustive analysis of the whole subject and an arrangement of its "facts and problems" in a systematic way.

The book is divided into four main parts, each part into sections and these again into numbered articles or topics. The parts are: I. Astronomy of the celestial sphere (144 p.); II. Astronomy of the earth-ball (104 p); III. Astronomy of the solar system (166 p.); IV. Astronomy of the star-universe (155 p.). As a further example of the nature of the arrangement of the book the sections in the second part may be given: 1. Earth-sphere; 2. Earth and sky; 3. Earth and sun; 4. Earth and ecliptic; 5. Earth-path; 6. Earth-form; 7. Gravitation; 8. Precession of the earth; 9. Earth-bodies; 10. Earth-tables. Each of these is discussed with considerable fulness but in an elementary way.

The most notable feature of the book is the large number of original diagrams. These are cleverly conceived and neatly drawn. They have a certain air of modernism about them and are very attractive. The plates contain good reproductions of photographs taken with the great telescopes. Another feature is the elaborate tabulation of astronomical facts, which appears to be a specialty of Professor Thomas. They are placed chiefly at the end of each part and summarize in condensed form the information given in that part.

One might be inclined to think that part four, dealing with the stars, is rather brief, considering the attention which has been given to it in the last thirty years, but it may be said that the most recent results and theories are included and the treatment is fresh, interesting and in simple, direct language.

The typography is exceptionally good, the pages being pleasing to the eye, and the binding is excellent. The book lies open at any page and it is easy to hold. C.A.C.

METEOR NEWS

Observations relating to meteors and meteorites are cordially invited.

WILLARD JAMES FISHER

It is with deep regret that we announce in these columns the death from heart failure of Dr. Willard James Fisher on Sept. 2, 1934, at his home in Cambridge. Dr. Fisher was born on Sept. 29, 1867, at Waterford, N.Y., and graduated in physics from Amherst College in 1892. He received the degree of Doctor of Philosophy from Cornell in 1908 and spent the next year studying at Göttingen. He was, at various times, associated with the departments of physics at Amherst, Cornell, and Clark Universities and served as professor in New Hampshire College, the University of the Philippines, and the University of Hawaii. He left the last institution in 1922 and came to Cambridge where he commenced a series of researches at the Harvard College Observatory. He was appointed as research associate at the Harvard Observatory in 1927, a position which he held until his death.

His work in physics dealt with gas viscosity, the height of the atmosphere, low sun phenomena, and the history of mechanics. Though entering the field of astronomical research later in life than most astronomers, Dr. Fisher's contributions in the fields of lunar eclipses and meteoric research have been of great importance. He successfully organized a group of special lunar eclipse observers throughout the Arctic and published significant work in this field. The major part of his time at the Harvard Observatory was, however, occupied in the study of meteors. He conducted a search of the vast collection of photographic plates at Cambridge and measured and catalogued all meteor photographs found. These exceeded five hundred in number, and in this way what is undoubtedly the world's most valuable collection of meteor photographs was made available for study and research. He was particularly active in investigating bright fireballs and the question of meteoric dust and created a popular interest in these matters throughout the New England States. An important paper by him on the distribution of iron meteorites is still in the press.

But Dr. Fisher's published works tell only a fraction of the story and his influence in arousing interest in meteoric research has been widespread. I take the liberty of quoting from a recent letter to the writer from Dr. Harlow Shapley, director of the Harvard Observatory. He says of Dr. Fisher, "I feel that we have lost a great deal in losing him, but his influence has been of permanent value and largely through him meteors are definitely in the Observatory program." The present writer owes his interest in meteors entirely to Dr. Fisher and can bear testimony to the fact that there was never anyone more ready with help and encouragement, or more willing to take time in assisting others with their difficulties. Dr. Fisher was indefatigable in collecting and indexing observations and information relevant to the study of meteors and meteorites and this material, which is almost all unpublished, was always at the disposal of those who wished to use it. The importance of meteoric research is better realized now than it was in times past and though Dr. Fisher has passed on, he leaves a lasting influence on the development of this branch of astronomy.

PUBLICATIONS ON METEORS AND METEORITES BY W. J. FISHER

The daylight meteor of Nov. 15, 1925. H.B., 827, 1925.
The fireballs of Dec. 29, 1925. H.B., 833, 1926.
The fireballs of Nov. 15 and Dec. 29, 1925. P.A., vol. 34, p. 421, 1926.
The apparition dates of the Andromede (or Bielid) meteor swarms. Proc. N.A.S., vol. 12, p. 728, 1926.
On the ratio of iron to stone in meteorite falls. H.B., 845, 1927.
Orientation and flicker in the luminous paths of meteors. H.B., 849, 1927.
The fireballs of 1927, Aug. 10. H.B., 851, 1927.
Preliminary report on a search for meteor photographs. H.B., 852, 1927.
The fireball of 1927, Aug. 13. H.B., 853, 1927.
Projects for meteor photography. P.A., vol. 35, p. 511, 1927.
Note on corrections to H. A. Newton's "1850 dates" of meteor showers. Proc. N.A.S., vol. 13, p. 578, 1927.
The trails of two periodically flickering meteors (with Esther Wurl and Marjorie Desmond). Proc. N.A.S., vol. 13, p. 540, 1927.
The fireballs of 1927, Oct. 16. H.B., 854, 1928.
Remarks on the meteoric procession of 1913, Feb. 9. P.A., vol. 36, p. 398, 1928.
Remarks on the fireball catalogue of Von Niessl and Hoffmeister. H.Cir., 331, 1928.
The Leonid radiant of 1898, Nov. 14, from Harvard photographs (with Margaret Olmsted). H.B., 870, 1929.

The Leonid radiant of 1901, photographically determined (with Margaret Olmsted). H.B., 870, 1929.

The fireballs of 1927, Aug. 10 and Oct. 16. P.A., vol. 37, p. 1, 1929.

Appeal for historical researches on the Leonids and other meteors. P.A., vol. 37, p. 345, 1929.

The curvature of a meteor path (with G. Z. Dimitroff). H.B., 877, 1930.

A Quadrantid radiant photographically determined (with Margaret Olmsted). H.Cir., 347, 1930.

The Quadrantid meteors, history to 1927. H.Cir., 346, 1930.

Catalogue of the Harvard Observatory meteor photographs (with Margaret Olmsted). H.A., vol. 87, p. 233, 1931.

Records of the Lyrid meteor shower of 1803. P.A., vol. 39, p. 256, 1931.

Remarks on the fireball catalogue of Von Niessl and Hoffmeister II. H.Cir., 375, 1932.

The fireballs of 1931, Feb. 4. P.A., vol. 41, p. 487, 1933.

Meteors of 1930, Nov. 19. P.A., vol. 41, p. 359, 1933.

On the finding of newly fallen meteorites. P.A., vol. 41, p. 246, 1933.

The penetration of iron meteorites into the ground. Proc. N.A.S., vol. 19, p. 286, 1933.

The Newton-Denning method for computing meteor paths. Proc. N.A.S., vol. 19, p. 209, 1933.

Mass and velocity of meteorites and the air density along their luminous paths. H.Cir., 385, 1934.

The history of the Giacobinid meteors. H.B., 894, 1934.

A relation between finds of iron meteorites in North America and glacial times. (In press).

P.M.M.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Increase of Interest in Astronomy

There have been many indications of the growth of interest in astronomy in recent years. In our own country of Canada this growth is shown by the addition of new Centres of our Society. There are now nine and others are under consideration. I should like to see one in the eastern provinces, as well as more in the west. This growth is parallel to that of our large observatories—first the Dominion Observatory at Ottawa, then the Astrophysical Observatory at Victoria, and soon the David Dunlap Observatory will begin operations.

Another indication is the remarkable movement for the making of telescopes by amateurs. For this the chief credit is due to Albert G. Ingalls, an associate editor of the *Scientific American,* who prepared the book "Amateur Telescope Making", now in its third edition. It is simply indispensable to the person who undertakes to make a telescope. Besides this, Mr. Ingalls gives every month in the *Scientific American* news of how the workers are progressing, with illustrations of their productions. This movement has spread to other lands and perhaps it will contribute to the development of international sanity, both in economics and in social relations.

The other day I received a catalogue of telescopes for the amateur, including a guide to the heavens. It is published by the Optical Research Associates (Box 33, Plainfield, N.J.), which organization, following the prevailing fashion, is known as the OPRA. The manager of its Telescope Mart is Professor Leon Campbell, 9 Vincent St., Cambridge, Mass., well known for his work in double stars and for his able organization of the public service of Harvard Observatory. The maps are drawn by Robert Barnes Butler and are creditably done. They will be very useful to the amateur, and the prices asked for the telescopes are very reasonable.

In the last received *Monthly Notes* of the New Zealand Astronomical Society is an account of the annual meeting of the Hamilton Astronomical and Meteorological Society, which is affiliated with

the New Zealand Society. The president, Mr. Allan Bryce, stated the aims of the society to be: To encourage members to do practical observational work with a view to co-operating with the observing sections of the New Zealand Astronomical Society, and with the rest of the world. To establish an observatory with a large-aperture reflecting telescope and a spectrohelioscope. To assist members in the making of their own telescopes. To foster and encourage the study of astronomy in Hamilton and district. Hamilton is about one hundred miles south of Auckland. The society has been offered a 14-inch reflecting telescope which will probably be erected in the Domain, or public park. An address was given in October, 1933, on telescope making, and twelve members expressed a wish to purchase materials for 6-inch telescopes. On July 9 nine were in various stages of construction, two others from outside districts had commenced the work, two excellent mirrors were completed and one was mounted and in use. I wish continued success to our Hamilton brethren on the other side of the earth.

In the *Monthly Notes* referred to in the preceding paragraph are reports on the various observing sections of the New Zealand Astronomical Society, which show that a large amount of creditable scientific work is being done. A request is made for information on the designing of sun dials. I might direct attention to the series of articles which have appeared in the *Scientific American* during the last few months.

Another Russian Publication

In 1932 the Engelhardt Observatory of the University of Kazan was reorganized and an astrophysical division was formed. From this there arose the need for the prompt publication of short papers, often of the nature of preliminary information and not suitable for the pages of the more elaborate astronomical publications. As a result of this, Number 1 of the Bulletin of Engelhardt Observatory has appeared. Its dimensions are 6½ by 10 inches and there are 16 pages in the first issue. It contains three articles: Preliminary notes on variable stars by D. J. Martinoff; On darkening at the limb in eclipsing variables by W. Krat; and The eclipsing variable RT Andromedae by N. Tchudovitchev. The articles are printed

in English and Russian in parallel columns, the mathematical expressions and tables being printed across both columns and serving for both languages.

The Size of our Galaxy

In the *Monthly Notices* for June of the present year is an important paper by Dr. J. S. Plaskett and Dr. J. A. Pearce of the Dominion Astrophysical Observatory, entitled "The distance and direction to the gravitational centre of the galaxy, from the motions of the O5 to B7 stars". This is a grand problem and on it these two astronomers have published some valuable papers, and a full discussion of their data will appear as the final part of volume five of the Publications of the D.A.O. The present paper extends to 34 pages and traverses the ground pretty thoroughly. The following are the dimensions of the galaxy as determined in this paper:

Distance from sun to centre	10,000 parsecs (32,500 l.y.)
Diameter of galaxy	30,000 parsecs
Rotational velocity at sun	275 km. per sec.
Period of rotation at sun	224,000,000 years
Total mass of galaxy	16×10^{10} times the sun

The Radcliffe Observatory

There are two well known observatories at Oxford, the Radcliffe and the University observatory. The former was named after Dr. John Radcliffe, a court physician who died in 1714 and who bequeathed a considerable sum of money "for charitable purposes". These words were interpreted rather widely and among other things his trustees erected at Oxford the Radcliffe observatory (1771-74), hospital and library.

The Radcliffe observatory has made many contributions to astronomy, its latest publication being "The Radcliffe Catalogue of Proper Motions in the Selected Areas 1 to 115", which has just been received. But with the passing years there have come changes in astronomical research and also in the property whereon the observatory was located, and the Radcliffe trustees in 1930 contracted for the sale of the site to Sir William Morris, of small-automobile fame, for £100,000. The Court sanctioned the sale, and a number of British

astronomers recommended that the trustees be allowed to accept the offer of the municipality of Pretoria, South Africa, to give to them about 57 acres of land on the range of hills known as Klapper Kop, about four miles from Pretoria, and that the trustees should apply a sum not exceeding £72,000 in laying out and building an astronomical observatory there, and in building residences suitable for a staff and in equipping the observatory with a 72-inch reflecting telescope and other necessary equipment. The balance of the fund was to be used for the maintenance of the observatory.

The University of Oxford opposed the scheme, mainly on the ground that it brought about a complete severance between the university and the observatory, but the Court found that the University had no legal right in the matter, although the observatory had been associated with it for so long. The trustees will now proceed with the development of the new great observatory. It is understood that the telescope will be similar to that of the David Dunlap Observatory.

C.A.C.

MEETINGS OF THE SOCIETY

AT LONDON

The May meeting was held in the Arts Building of the University of Western Ontario, the president, Mr. George Gunn, in the chair.

The president exhibited an 8-inch lens he had procured for a new telescope he is making.

The speaker of the evening was Dr. H. R. Kingston, whose subject was "The Earth as an Astronomical Body". Before beginning his subject Dr. Kingston spoke of the interesting visit he had made to the David Dunlap Observatory and of the progress made in getting the mechanism ready for the great mirror. Beginning his subject, the speaker asked, "Why study the earth in this society?" To illustrate the reason he showed that in order to get a base line for measuring the distance to the moon, we must know the size and shape of the earth.

The speaker outlined the progress of the spherical conception of the earth from the time of Eratosthenes, 200 B.C. When he visited Egypt he noticed that the pole star was less in altitude than in Greece and judged that he had travelled over a curved surface. When in 1450 the introduction of printing made the ancient philosophies more widely known, Columbus read, believed and had the courage to put his belief to the test. Commonly accepted proofs of the rotundity of the earth were examined by the speaker. The oblateness of the sphere is shown by reckoning the distance one has to travel north, to make the pole star change one degree in altitude. The difference between the equatorial and the polar diameter of the earth is only 26 miles.

The matter of rotation was next discussed. Foucault's pendulum which was hanging in the room, was explained and set in motion. In half an hour the members could see a change in the plane of its vibration. At London the length of time required to complete the circle of vibrations is 35 hours 12 minutes.

The speaker showed how to calculate latitude and longitude, the first by means of the altitude of the pole star and the second by determining the difference between local time and that of Greenwich.

In conclusion Dr. Kingston explained the meaning of travelling by a great circle, and showed how 250 miles are saved in going from San Francisco to Yokohama by this method of navigation. Much discussion and many questions showed the interest taken by the members.

N. Morris, *Secretary.*

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